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GLOBAL CLIMATE CHANGE AND NATURAL DISASTERS: A THREAT TO SUSTAINABLE FOOD PRODUCTION AND FOOD SECURITY OF PAKISTAN

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ABSTRACT

Since the last few decades, climate change had hardly hit the poor economy-holding countries, Pakistan is among these which is very prone to climate disasters due to its geography. This study is analyzing the climate change in Pakistan by reviewing the negative impacts in terms of disasters on the economy and livelihoods. Geographical location, socioeconomic factors and continuous episodic climatic fluctuations around the globe have made Pakistan much vulnerable climate disasters like droughts, floods, extreme events, etc. Therefore, this study is concluding by highlighting the susceptibility to food security and the economy of Pakistan considering the negative impacts of disasters undergoing due to climate change. It moved towards the past to have an overview where and when Pakistan was hardly hit by severe hazards and what losses it brought to economy and livelihoods in the last few decades. Further, this paper is expressing the local scale vulnerability to diverse disasters by analyzing natural or human-intervened factors. Furthermore, it expresses about the incidence of poorest towards climate disasters considering the geographic, climatic and socioeconomic factors of each region. Finally, it suggests that the countries like Pakistan are in dire need to quickly address the negative impacts of climate changes regionally and locally to overcome the losses by giving mitigation and adaptation approaches instead of wasting resources towards recovering.

Keywords: Global climate change, physical disasters, Pakistan, food security, vulnerability

INTRODUCTION

It has been strongly evidenced by the Third Assessment Report of the Intergovernmental Panel on Climate change (IPCC) that Climate change is affecting most of the countries in the world (WATSON, 2001). An increasing trend has been reflected from the world statistics regarding the pattern and frequency of natural disasters, ranging from floods, earthquakes, and cyclones to human

caused disasters like population conflicts, accidents etc. (LERNERLAM, 2007). The losses due to impacts of such variabilities in climate differ across the world (SAYED, 2014). Some notable reasons for happening this mostly in developing countries are e.g., rapidly growing population, outrageous use of resources, constraints and restrictions regarding infrastructure and most prominently the less adaptability to natural disasters (IPCC, 2001).It has been found that less developed countries are more prone to natural disasters because of which world's 95% deaths due to these disasters happen in developing countries because of low adaptive capacity among people (IPCC, 2001). Compared to developed countries the losses other than deaths are twenty times higher in developing countries (SAYED, 2014; CARDONA & CARREÑO, 2013; CRUZ et al., 2007). The rugged, terrain, unregulated and variety of geographical locations along with uncontrolled encampment, lack of education and increased population are the main contributing reasons which make a country more vulnerable to the impacts of climatic fluctuations (ARIF & FAROOQ, 2012).

There have been observations with considerable rock evidences that processes or Earth warming has been happening since middle and late 19^{th} century (BÖHM et al., 2010; ROHDE et al., 2013; SCREEN & SIMMONDS, 2014). Earth mean temperature has been increased by 0.8°C since middle of 19^{th} century where the records for warming trends were seen over three surfaces independently for land, sea, and ocean (IPCC, 2007). Climate change can be caused by three major reasons, firstly due to natural factors variability and disturbances, secondly from human based activities like the emission of greenhouse gases (GHG) which includes the Carbon dioxide (CO_2) and methane mainly, and thirdly from land use changes which are due both natural and human based factors. There happened a dramatic variation in levels of CO_2 which have risen from 284 ppm to 397 ppm in the period of 1832 to 2013 according to the NOAA's report and meanwhile it has been strongly evidenced that there is theoretical relationship between GHG and global increase in temperature (BUCHWITZ et al., 2018). It has been observed that human activities which the burning of fossil fuels increased the temperature of earth to a greater extent whereas land-use changes contributed too but to a minor extent (STATES, 2013; THE ROYAL SOCIETY, 2010). So, climate change has brought and expected to produce fluctuations in frequency and patterns of rainfall, warmer temperatures, more extreme weathers etc. Compared to the end of the last century, the global mean atmospheric temperature is expected to rise by 1.8°C to 4.0°C by the end of current century (SOLOMON et al., 2007). Different studies have found that warming trends across the

globe will be evenly distributed, more likely the land will be more prone to be warmed than oceans towards poles and in arid areas (SOLOMON et al., 2007). Because of enhanced absorption of CO_2 by oceans, the warming of land surfaces is increasing slowly than observed through climate models as evidenced by recent climate records (BALMASEDA et al., 2013). Sea-level rise due to earth warming is expected to make the coastal areas more vulnerable to flooding. Variability pattern of precipitation is still uncertain over tropical regions because impotence of climate models to represents the global hydrological cycle more authoritatively (LORENZ et al., 2012). Generally, it is expected that summer monsoon in Asia will increase because of climate warming (SOLOMON et al., 2007).

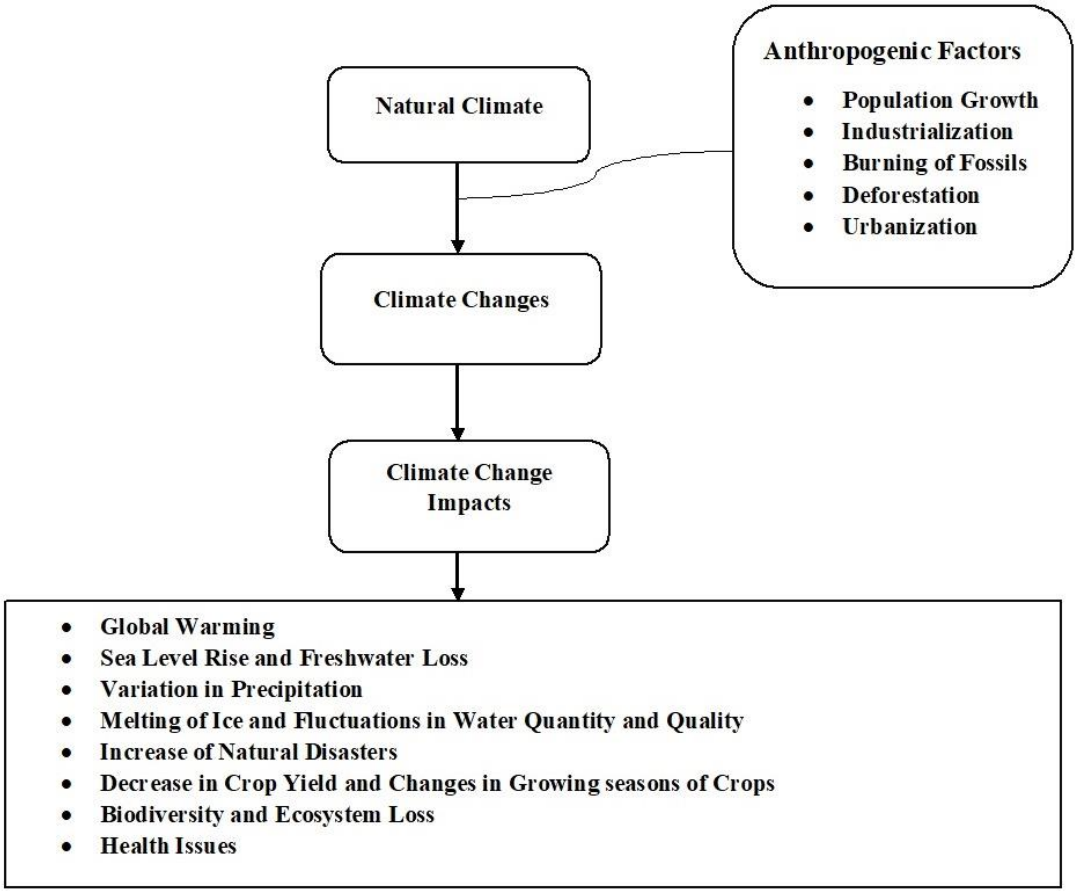

Figure 1. Share of anthropogenic factors in climate change and its impacts.

Most of the climate change impacts are experienced in developing states due to lack of necessary resources for mitigation and adaptations against climate change though it is a global phenomenon. Major impacts of climate change are on agriculture sector in developing nations due

variations in precipitation frequency and intensity, floods, droughts, and less availability of water and land resources. Pakistan is one of countries in world which is highly susceptible to climate changes as its economy is dependent on agriculture which is a climate sensitive sector. Pakistan is among the top ten countries severely struck by climate change where large population comprised of poor and less adaptive people to climatic variability, as affirmed by the statistics of Global Vulnerability Index. Pakistan has strongly hit by climate changes northern areas are disposed to snow and landslide stresses along with floods. Pakistan is facing the continuously increasing trend for warming since beginning of last century where the temperature has already increased by 0.6-1.0℃, coastal areas suffered from the decreasing trend of rainfall by 10-15% and humid areas produced the increased precipitation by 18-32% in monsoon zones (FAROOQI et al., 2005). Central parts of country are always susceptible to flood stresses during heavy monsoons in summer, coastal areas are subjected cyclones and flooding because of warming trends while southern parts of all provinces other than Khyber Pakhtunkhwa (KPK) are more prone to drought stress (SAYED, 2014). In recent years, the climatic stresses have more evident, intense and frequent resulting in making the regional societies of the country more inclined to such disasters e.g., floods (Atta-ur-Rahman & Khan, 2011), droughts (Anjum et al. 2012), heat waves, cyclones landslides etc. (FAROOQI et al., 2005).

The impacts of climate change and associated stresses are responsible for deaths of people every year e.g., flood stress from 1993 to 2002 caused the death more than 6 thousand people along with about 9 million people being affected by this stress in this period (RAFIQ & BLASCHKE, 2012). The flood in 2010 was biggest climate disaster to Pakistan economy which effected almost 20 million people with heavy economic losses, according to National Disaster Management Authority (NDMA) report. It has been observed that climate stress in kind of flood which hardly hit to Pakistan in 2010 effected the rural poor community, created several food security issues in urban parts, demolish the communication, energy, transport, water control, and livelihoods of people (KHAN & SALMAN, 2012). Economically Pakistan needs to face heavy losses due to climate stresses and disasters every year as what happened in 2010, agriculture, being the main pillar of country's economy, the standing crops were completely destroyed and pushed the society into poverty (ARIF & FAROOQ 2012).

Main problem with authorities in Pakistan regarding climatic stresses and particular natural disaster management, they only focus on consolation and rescuing processes rather than focusing

on awareness among people understanding the processes involved in stress identification, assessment of risk and its management. Spreading the information about the link between people's livelihoods and stress readiness should be the main focus of country's authorities which unfortunately presently not happening (RAFIQ & BLASCHKE, 2012). Readiness for climate disasters decreases the susceptibility of poor people to climate stresses. Most remarkable risk factors which are responsible for the increase in susceptibility and make the climate stresses severer in Pakistan are; lack of early or poor warning systems; lack of awareness and education; limited skilled manpower and most prominently no coordination among various government authorities etc. makes large number of people vulnerable to climatic disasters (FAROOQI et al., 2005).

Under this consideration, this paper describes the main physical disasters e.g., drought, flood, land-sliding, cyclones etc. by highlighting the impacts and the vulnerabilities due to these stresses to Pakistan's economy. This paper reviews applicable literature and aiming to document the conceptual relationships between the impacts of climate stresses and disasters on economy and food production by considering the vulnerability along with impacts as well. Moreover, the importance of impacts is described here to notice which regions are more susceptible due to those impacts of climate change. At the later parts of the paper, disasters impact and their vulnerability exposure to Pakistan's economy is discussed with concluding remarks.

CLIMATE CHANGE DISASTERS IN PAKISTAN

Annual GHG emissions have nothing to do with climate change, instead total amount of GHG in atmosphere have the primary influence on climate change. Least developed and developing countries have limited share in climate change but the developed countries have stocked the GHG in the atmosphere by more than 75% of the total global stock. Pakistan, a developing country in the world is relatively more vulnerable than other countries because of some reasons, the major one is that its economy is mostly supported by the climate sensitive pillars of the state i.e., agriculture, forestry and deltas which always threatened to flooding during monsoon. Because of several human forced activities and nature variations, Pakistan's mean annual surface temperature has been rising since the start of the last century. Mean rise in temperature in several parts of the state is shown below in Table 1.

Table 1. Temperature change during 1951 – 2000 in Pakistan (Source: FAROOQI et al., 2005)

Serial No.	Region	Trend	Range
1	Thermal Low Region	Increased	0.2 to 1.0°C
2	Baluchistan	Decreased	- 0.5 to -1.5°C
3	Monsoon Belt	Decreased	- 2.0 to 0.0°C
4	Himalayas	Increased	-1.5 to 1.5°C
5	Thar	Increased	0.3 to 1.00°C
6	Sindh	Increased	0.0 to 0.5°C

Due to this increase in temperature, various fluctuations in rainfall and sunshine were also noticed as the variation in precipitation in shown below in Table 2.

Table 2. Precipitation variations during 1951-2000 in Pakistan (Source: FAROOQI et al., 2005).

Region	Annual Mean Basis	Monsoon Basis	Winter Basis
Coastal Baluchistan	-ve	-ve	+ve
Quetta & Sindh	+ve	+ve	+ve
Western Baluchistan	-ve	-ve	-ve
Monsoon Belt	+ve	+ve	+ve
Himalayas	+ve	+ve	-ve

Pakistan's annual precipitation lies between the ranges of 250-300 mm as the state position is at the dry region of the earth if it is positioned geographically. More than half of the annual rainfall of the state comes during monsoon period in summer but summer is relatively very hot and winter comparatively cold and dry. Due to the variety of geological, meteorological and topographical factors in state making it very prone to climate disasters (KHAN & KHAN, 2008; RAFIQ & BLASCHKE, 2012). Pakistan, a developing country, geographically it is positioned as an arid country in the Asia and South Asian countries. Pakistan constitutes a huge area for arable land but most of it is reported as arid which is more than 80% of the country's total area and only 8% reported a humid (AKHTAR, 2010). Because of the most the arid land, as the economy is supported by agriculture, so to make this arid land an arable land, the state mainly depends on irrigation system which is supported by mainly by Indus river. Pakistan's total land is more than 79.6 m ha out of which only 1/4 is suitable for agriculture sector either through rainfed (4 m ha) or through artificial irrigation systems (16 m ha).

FLOODS EXPERIENCES OF THE STATE

Considering the most habitual and suffering climate disasters in terms of food security, human privation and economic loss, floods will be at the top. The most associated damages with floods are loss of infrastructure, foods, homes, farms, livestock etc. Pakistan among the South Asian countries ultimately exposed to the floods and storms that normally comes and originate from India and Bengal during monsoon period. Pakistan had to face the historical and devastating floods in 1950, 1992, 1998 and 2010. Most of floods occur during summer and monsoon period when the glaciers are melting, and floods mainly hit the Punjab and Sindh provinces. Over the years the frequency and intensity of floods is increasing with huge losses to the state's economy, though various investments have been made regarding rivers' control. Annual floods in 2007,2008, 2009 the floods hit hardly to the Punjab and Sindh provinces where 300 people died with 2.5 million affected directly or indirectly, more than 80,000 people migrated and displaced, and dozens were died, respectively (AZAD & MCELHINNEY, 2011). In Pakistan flooding is considered as the most damaging and devastating climate stress as in 2010, according to the NDMA report flood killed more than 1,800 people, more than 20 million were migrated and displaced along with 3,000 injured. Around 78 districts were hardly hit by flood in 2010, overwhelmingly all districts were from Punjab and Sindh province (UNOCHA, 2002). Later, the flood in 2011, was also damaging for states economy as it greatly influenced the infrastructure, livestock and standing crops, along with about 9 million people were affected, according to NDMA. Since last half century, Pakistan had to face the 400 billion losses to its economy due to the floods that occurred in past.

IMPACTS OF FLOODS ON FOOD SECURITY

The geographical position of Pakistan makes the Population of the state vulnerable to high risks of climate disasters. The condition of the exposure and impacts of disasters on population becomes more havoc as most of the people are less aware, literacy rate is not so high in remote areas of the state, unavailability of social nets in backward regions, less coordination between government authorities and local communities that how to reduce risks. There can be taken some major incentives regarding reforming the system which depends on the severity of the disaster during a disaster is happening. Most oftenly the incentives should include featuring collaborative

dependence, highlighting major deficiencies among government authorities and practices. As for example, there should be an early warning system as once the intensity and frequency perceived to minimize the losses of lives and losses through efficacious collaboration which gives more time to people to get migrated to some safe places where they can minimize their economic losses (livestock, essential possessions etc.). The floods and their impacts patters to food security is;

- **Loss of Crop Production:** floods in Pakistan devastate the major and minor crops which include millet, sorghum, groundnut, soybean, cotton, rice, and sugarcane etc.
- **Impacts on Livelihoods:** There happens an intensive loss as result of devastating floods to farmers' crops, seeds, irrigational infrastructure, farms, livestock, and other valuable assets.
- **Loss of Food Availability:** As the production of food is being affected by floods, ultimately the availability of food will be impacted negatively too. Increase in price in markets and high rates of unemployment during flood periods make the food more unavailable for poorest families.
- **Impacts on Food Access:** Flood impacts negatively from food production to food procurement which make the staple food unavailable.
- **Impacts on Food Consumption:** During flood periods the quantity of food consumption normally reduces greatly because of two major reasons i.e., unavailability and more costly food which leads to low quality food and overall shortage of diet.

DROUGHT OCCURRENCE IN PAKISTAN

Since the history of human being on this earth, drought is a periodic and very normal feature which has anguished the mankind. As Pakistan fall in arid region, so the state has to face recurrent droughts because of variations in precipitations. Drought has noticeable outcomes both in developing and developed countries and it affects nearly all regions of the globe, but it is more shattering for developing countries like Pakistan where agriculture is comprised of both irrigational water as well as the rainfed farming. Assessment of outset of drought, range, potency and duration can reduce the impacts imposed by drought, and there would be some incentives for the provision of development of mitigation response against drought stress. Drought stress events in last 50 years in Pakistan and losses due to these stresses clearly dragged the state to be vulnerable against

drought due to limited contingency policies. There is a dire need for the countries like Pakistan to blend the current drought monitoring tools to limit the continuously vulnerability of drought in state. Considering the reduction of vulnerability to drought in Pakistan, it is ineluctable to gauge related impacts and locating prospective reasons.

There are actually four categories of drought, Meteorological, Socio-economic, Hydrologic, and Agricultural droughts. Unfortunately, Pakistan had to face all these four kinds of drought since last few decades. Droughts, with varying properties, can occur in any region either for short-term or long-term depending on the characteristics of that region (KHAN AND GADIWALA, 2013). Because of low annual precipitation and various socio-economic factors, some parts of the Sindh and Baluchistan provinces have to face droughts. As drought is a composite process because it is closely related to socio-economic activities, in Pakistan it becomes more complex because of several reasons which include mainly high poverty index, irregular use of water and land, non-adaptive land, deforestation and overutilization of groundwater. According to the previous reports, it has been found that droughts in Sindh and Baluchistan provinces during 2000 and 2002 were devastating forced over 3 million people to migrate along with billions of dollars of loss to economy (Larsen et al., 2014). Because of high poverty index, occurrence of drought also brings various indirect impacts like disease outbreak which is sometimes very epidemic.

LANDSLIDE INTENSITY AND FREQUENCY IN PAKISTAN

Pakistan's northern areas, several parts of Khyber Pakhtunkhwa are comprised of high mountains which are always prone to landslide events. Lack of collaboration among government authorities and local communities, irregular farming, unplanned agricultural cultivation, high deforestation and uneven infrastructure development and frangible soil type are the main cause of landslide events in Pakistan. Several landslide events have been observed since last half century which killed more than 400 people because northern areas are the tourist's sites in Pakistan (LARSEN et al. 2014).

PAKISTAN'S EXPOSURE TO CYCLONES

Coastal areas of Pakistan are always disposed to another kind of natural climate hazard i.e., cyclones, though they are not too frequent but have caused various kinds of losses. Because of the recent climate change in Pakistan, Sindh province have become more vulnerable to cyclones because the intensity, and frequency have been exacerbated. Considerable losses have been reported in terms of livelihoods, infrastructures, properties, because cyclones mainly target the socioeconomic activities of the region it hits. According to the various compiled reports, during 1970 to 2001 the coastal areas of Pakistan had to face several kinds of cyclones which killed more than 500 people and directly impacted about 2 million people along with heavy loss to economy which consisted of billions of rupees (LARSEN et al., 2014).

RELATIONSHIP BETWEEN CLIMATE HAZARDS AND POVERTY

It is normally perceived although climate change affects all regimes of globe and all kind of people are suffered from it, but most oftenly poorest communities are hardly hit by these calamities. Before moving towards the impacts of climate hazards on different kinds of communities, firstly it is needed to identify and differentiate between poor and rich at regional scale (ADGER, 2006). In Pakistan, the poverty index has been classified and based mainly on socioeconomic factors, agricultural sector and agro-climatic factors of that region along with household incomes and expenses' surveys (CHEEMA & SIAL, 2012; MALIK, 2005). In Pakistan the classification of communities and mentioning a respective group of people to be poor is based on the landless or small landowning communities, workers, sharecroppers. After classifying the population either rich or poor, the next step comes make the relationship between climate change hazards and poverty among people. The impacts of climate hazards on the people are most destroying as they are vulnerable to disasters due lack of suitable resources and adaptation measures (BOHLE et al., 1994). Punjab, the most populated province of Pakistan, is most vulnerable region in the state to the impacts of climate hazards as remote areas still in lack of education, health basic necessary facilities. But the impacts assessments showed that the vulnerabilities to the impacts of the climate stresses was very uneven as within a community there are several kinds of people i.e., rich and poor. Poor people don't have enough resources to build

strong infrastructure as one of the mitigation or adaptation approach, that's why they are more attacked and suffered by these climate hazards. Their infrastructure cannot stand firmly during the stress days for example in floods, that's why they are more negatively impacted by physical hazards (O'BRIEN et al., 2007; MALIK, 2005).

IMPACTS OF CLIMATE CHANGE STRESSES ON FOOD PRODUCTION OF PAKISTAN

Among all the economic-based sectors, agriculture is the most endangered field due to global climate change. Since last half century, Pakistan had to face various kinds of physical climate disasters e.g., intensive rainfall which brought heavy floods, extreme temperature events, heat strokes etc. which caused heavy losses to agricultural sector and livelihoods. It is presumed that according to Geography and human activities in Pakistan the climate will continue to change in Pakistan. There are five major crops in agriculture sector of Pakistan, Wheat, Maize, Rice, Sugarcane, and Cotton that need significant attention to stable the country's economy and human livelihood through critical adaptation measures against climate change. Most of the rural population in Pakistan and in other developing countries is dependent on agriculture, therefore the adaptation strategies against the negative impacts of climate change are necessary though all rural household don't follow these strategies.

Climate change impacts are differently dispersed geographically though on larger scale it has minor effects on global food security. Developed countries are occupied with adaptation strategies but developing and least developed countries are suffered due climate change. The least developed states in South Asia and Africa mostly follow the subsistence agriculture, because technically they are in lack of technicality and financial resources to mitigate or adapt to the negative impacts of climate change. This, ultimately destructively impacts these countries because their livelihoods. Different studies have reported that changing patterns of precipitations and fluctuations in temperature have worthwhile impacts on global and regional food productions (JANJUA et al., 2010; MAHMOOD et al., 2012). According to the report, wheat which is a staple food for most of the South Asian countries, production will decrease by more than 50% by 2050. It has been observed by several studies that if climate change remains unabated the South Asian countries will have to face more than 40% agricultural losses because of global warming. As the

cost to adopt in changing climate is very high for least developed countries, hence it causes considerable threats to food production and food supply (ARNELL et al., 2004).

Climate change stresses challenges the sustainable food production globally and regionally. Considering the variation among the impacts of climate change that vary at every scale of its incidence but generally it is expected overall food production will decrease (GODFRAY et al., 2010; LOBELL & FIELD, 2007). Due to fluctuations in precipitation and temperature and occurrence of extreme weather events imposing serious threats for farmers. As agriculture is a nature-based activity sector that's why it is always highly dependent on climate fluctuations. Increasing intensity and frequency of extreme weather events all around the world effected the farmers through distorting their agriculture specifically in least developed countries. Globally the farmers every year have to face the disasters like, droughts, floods, pests and diseases etc. (IQBAL et al., 2016; ULLAH et al., 2016). There are many kinds of susceptibilities to agriculture sector but there are five mentionable here; firstly, the production risks related to decline in crop productions due to extreme events, pests etc., secondly, financial risks, farmer's inabilities to pay the remaining for inputs, thirdly, market risks, which includes price fluctuations, fourthly, environment risks and finally the human resources risks. As the subsistence farmers can also be categorized in to large and small landholders. Large landholders carry more land for diversifying their income and crop productions. Hence household's socioeconomic and other linked disaster factors are also important in notifying the risk capacity of any farmer. As in 2005, Pakistan had to face historical earthquake but till now the states' system has not institutionalized well against the preparedness of natural disasters. Therefore, it is recommended for farmers as well as the local authorities to ascertain the risks of any type to stabilize their production (DROLLETTE, 2009).

RELATIONSHIP AMONG CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY IN PAKISTAN

Climate change disasters affect the agricultural productions and food security because of many factors, like precipitation fluctuations regionally and globally, access to resources, capital availability, access to water, land and other inputs. Considering these reasons, doubts regarding food security and trade dynamics are increasing continuously because agriculture sector will have to feed more than 9 billion people by 2050. Due to the continuously increasing population, the

world water requirements have also been increased and according to different reports the irregular withdrawals of water for agricultural purposes will create some socioeconomic issues (FISCHER et al., 2007). Even though globally the world irrigational systems have upgraded and still on way of its more upgradation, but irrigational withdrawals will increase up to 20% by 2080 with 45% more irrigational water requirements.

Climate change impacts, although on global scale are generally negligible but at regional scale specifically for developing countries like Pakistan, they cannot be neglected. According to the geography of Pakistan in South Asian countries, mostly the summers are hot and winters are cold and freezing. The state has diversified geography characteristics e.g., mountain, plains, deserts coastal areas etc. Each geographical region has different climatic conditions, like some are very cold and some are very hot while some remain under moderate weather conditions around year (YOUSUF et al., 2014). Among the countries where the poverty index is very high and mostly based on agriculture, there the agriculture plays an important role to make certain the food security to decrease the poverty. Nature affects agriculture positively or negatively in terms of temperature fluctuations, changes in irrigational water availability, variations in evapotranspiration and heat. Considering the vulnerability index of Pakistan in comparison to other countries globally, it is very high because of contrasting climatic conditions. Since last few decades state had to face the disasters which impacted negatively on to ensure the food security along with losses of infrastructure, valuable amenities of people, and mainly the standing crops were destroyed which ultimately caused huge losses to the economy (YOUSUF et al., 2014).

Adaptation, which has varied kinds of definitions, is needed against climate change in least developed countries though they are not great contributor in changing climate but to ensure food security. Best and understandable definition of adaptation was given by IPCC, according to which "*The adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".* Some studies focused adaptation by considering in a very broader way which included the improvements in societies (LOBELL & FIELD, 2007). Furthermore, climate change adaptation has various classifications instead of spatial one, which include financial, behavioral, technical, institutional, and informational (ADGER et al., 2003). Therefore, climate change has close links with vulnerability and susceptibility as well. For example, farmers in various African countries adapted well to reduce their vulnerability index and

to ensure food security by taking steps like changing in planting dates, variations in crop varieties, changing dates of inputting amendments like water and fertilizers etc. (BRYAN et al., 2009).

Pakistan is supposed to be among the countries that are highly vulnerable to climate change and face many difficulties because of climate change disasters to fulfill the food security requirements. Pakistan's economy is mainly based on agriculture sector which shares 19.8% to the GDP and provides employments directly or indirectly to more than 42% population along with direct livelihood provision for 62% population (MUHAMMAD et al., 2012). Apart from the importance of agriculture for the state, Pakistan's agriculture sector is facing momentous challenges due climate change and disasters like extreme events, change in temperature, variations in rainfall patterns, pests, diseases, and fluctuations in productivity of major crops (SMIT & SKINNER, 2002). Pakistan is highly vulnerable to climate change because its economy is based on natural resources, therefore necessary adaptation measures at regional scales are needed to ensure food security.

MAJOR AGRICULTURAL FOOD CROPS IN PAKISTAN AND THEIR CLIMATIC CHARACTERISTICS

The agriculture proves as livelihood source for Pakistan because state's economy is mainly based on agriculture sector. In the developing countries like Pakistan, major aim of the agricultural sector is to fulfill the food requirements to ensure the food security through increased productivity of major cash and catch crops and reducing the poverty. There is a high vulnerability index of Pakistan, one of the major reasons is geographical position on the world map along with increasing population, and less technical resources. Climate disasters imposes a damaging threat to Pakistan's economy by challenging its crop productivity, water resources availability and energy issues along with possible variations in extreme events and weather patterns. One of the greatest examples of above-mentioned susceptibilities is the melting of glaciers ice and the melting speed is much faster as compared to other countries. Pakistan falls among 7 countries list where 65% population is facing the food insecurity issues (FAO 2013). Most of the Asian and African countries are unable to take necessary actions regarding food insecurity problems (FAO, 2014).

Wheat is major cash and food crop in Pakistan which is considered as a staple food. Other than wheat, cotton, maize, rice and sugarcane which collectively contributes about 32% in value

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addition according to the recent statistics. Many kinds of agricultural products and state is self-sufficient in terms of staple food (GERA, 2004). Besides the efforts made by various government institutions and government authorities, it has been found that about 22% people are considered as food insecure (FAO, 2014). Pakistan authorities ignore other crops by focusing only on the wheat policy making as it is the staple food for most of the parts of the state. If we consider the arable and cultivable land in Pakistan, due to scarcity of irrigational water only 6.34 million ha is based through canal irrigation system, and about 12.52 million ha is cultivated through secondary sources like tube-wells etc. The remaining 3.59 million ha is totally rainfed without having any source for irrigation (PAKISTAN ECONOMIC SURVEY, 2017). It is expected, in near future the scarcity of water resources will be more severe and will cause negative impacts to major crops in Pakistan.

There are many kinds of agricultural crops which are grown in Pakistan but four major crops are adopted by all subsistence farming holders and large landholders. We take examples of relationship features of climatic variables with crop productivity from the reports of Pakistan Meteorological Department who devoted the destructive statistics of Pakistan, among four major crops of Pakistan the mean yield for sugarcane was highest followed by maize, wheat and rice, whereas in case of average annual yield increase, the trend was different as wheat ranked first along with highest production area. If we compare the climatic variables for different major crops, highest minimum temperature and lowest minimum temperature were observed during rice and wheat growing seasons, respectively. Highest rainfall occurred during rice growing season whereas lowest was seen in maize growing season around the country. The values regarding the statistics of climatic variables and variations in crop productivities among different major crops is given in Table 3.

Table 3. Climatic variables and descriptive variation in drop productivity (Source: PMD, 2015)

Variables	Major Crops	Values			
		Mean	Std. Dev.	Min.	Max.
Cropping Area (ha)	Wheat	93.74	80.16	2.10	324.50
	Rice	10.63	12.04	0.00	43.70
	Maize	15.89	16.70	0.90	52.20
	Sugarcane	20.63	34.18	0.00	126.40
Production (tons)	Wheat	210.21	209.57	2.90	901.70
	Rice	17.21	18.13	0.00	83.40
	Maize	27.44	27.07	0.80	137.10
	Sugarcane	1018.16	1707.40	0.00	6403.80
Yield (kg/ha)	Wheat	879.91	262.46	252.53	1912.22
	Rice	737.29	273.73	303.52	1315.23
	Maize	949.31	1038.17	287.11	9307.80
	Sugarcane	18,284.91	3603.22	8498.42	29,454.20
Max. Temp. (℃)	Wheat	25.50	3.44	14.47	29.96
	Rice	36.91	2.00	32.40	42.90
	Maize	32.39	3.46	24.95	38.67
	Sugarcane	28.86	3.25	22.70	35.15
Min. Temp. (℃)	Wheat	10.85	3.11	1.37	15.64
	Rice	24.84	1.71	19.68	29.16
	Maize	18.29	3.87	9.93	28.42
	Sugarcane	14.81	3.17	8.86	21.48
Rainfall (mm/year)	Wheat	22.28	17.58	0.00	71.18
	Rice	70.89	60.02	0.00	322.58
	Maize	33.56	21.80	3.58	112.98
	Sugarcane	28.76	20.24	0.25	132.16
Humidity (%)	Wheat	57.43	6.71	36.17	70.20
	Rice	58.57	5.90	44.80	74.00
	Maize	51.34	5.80	37.25	64.25
	Sugarcane	60.35	5.87	43.55	73.43

CLIMATIC VARIABILITY AND RICE PRODUCTIVITY IN PAKISTAN

Second largest GDP sharing crop in agriculture in Pakistan after wheat is rice which is also an exportable commodity for the state. Since last decade, all climatic variables except maximum temperature proved as significant contributors in the yield of rice. Whereas, minimum during rice season all around the rice growing areas in Pakistan negatively impacted since last decade. Along with minimum temperature variations in precipitations and sunshine hours also negatively

impacted the productivity of rice. The impacts of rainfall on rice productivity are less obvious as compared to the impacts of maximum and minimum temperature (SARKER et al., 2012), but overall all climatic variable impact the rice production by this way or that way which vary among different kinds of rice. There are two linked perspectives of temperature to enhance the production, firstly if the mean maximum temperature will increase the rice production will enhance and secondly if minimum temperature will be higher the yield will increase (SHAKOOR et al., 2015). But some studies pointed out some general point of views that increase in precipitation and temperature will negatively synchronize with rice production (PENG et al., 2004).

CLIMATIC VARIABILITY AND SUGARCANE PRODUCTIVITY IN PAKISTAN

Sugarcane is considered as one of the cash crops in Pakistan and it brings a lot of earnings to the subsistence farmers and to the economy of country. Sugarcane is planted normally in Pakistan in two seasons, autumn and spring. Since the last decade it has been found that maximum temperature negatively impacted the crop productivity, meanwhile minimum temperature that prevails during growing season along with the increase in humidity enhanced the productivity significantly. Overall, sunshine hours negatively impacted the production of yield according to the reports of Pakistan economic survey of last decade along with reports of meteorology department. So, it can be deduced that maximum temperatures, humidity and minimum temperature enhanced the yield significantly.

CLIMATIC VARIABILITY AND MAIZE PRODUCTIVITY IN PAKISTAN

Maize is considered as major food crop after wheat and rice in Pakistan as well as the raw material for many exportable commodities. Since the last decade, maize suffered a great fluctuation in productivity, and generally the yield on average basis decline in last ten years (ALI et al., 2017). Increase in rainfall, sunshine hours and humidity during maize season either spring or regular maize, it negatively impacted the yield of maize crop. If temperature factor is considered, minimum and maximum temperature positively impacted the yield of maize crop in optimum limits.

CLIMATIC VARIABILITY AND WHEAT PRODUCTIVITY IN PAKISTAN

Among all the food crops grown in Pakistan, wheat is considered as the staple food for major portion of population of state. Sowing time is winter and harvest in summer. During sowing time decrease in temperature proved opportune for better growth, whereas if high temperature prevailed then it caused delay in germination, and damaging for seedling growth. Considering the rainfall and flooding periods during harvesting time which have caused food insecurity issues by causing yield losses during harvesting (JANJUA et al., 2010). Since last decade, the possible reasons for average wheat yield decline were longer low temperature conditions along with uneven precipitation patterns. Maximum temperature if prevailed during any growing stage, it negatively impacted the productivity. But minimum temperature influenced the production positively when it prevailed during the sowing periods. Increase in sunshine hours also negatively influenced the yield of wheat. It has been found from the previous reports, that fluctuations in minimum, maximum, or mean temperature can cause significant changes in wheat production (TARIQ et al., 2014).

SUGGESTIONS AND RECOMMENDATIONS TO ENSURE FOOD SECURITY IN PAKISTAN UNDER CLIMATE DISASTERS

To ensure the food security in Pakistan and other developing countries, climate disasters make it a tough task. As described earlier, people in Pakistan are more susceptible to food insecurity due climate change disasters. Pakistan should make the integral part of its strategic work plan to manage the climate disasters to ensure the food security by using the available resources. Following are the recommendations and suggestions based on the literatures described earlier;

REDUCTION IN RISKS AND MINIMIZING LOSSES AGAINST NATURAL DISASTERS

Since Pakistan came into existence, there are many kinds of governing bodies and government authorities are working but only to the paper work but in real the state is lack of financial resources, skill availability, political interests, and coordination among local communities and government bodies. The state is actually lack of practical work at small local and regional scale where bulk of work should have been done. Unfortunately, Pakistan’s governing bodies are mainly

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focusing on the response mechanisms of every kind of disaster instead of working on prevention, mitigation and adaptation dimensions of disasters.

TEMPERATURE STRESS AND ENSURING FOOD SECURITY

Access to technology should be ensured at local level to avoid the risk of disasters, e.g., disseminating the smartphone technology at local and regional scale to make connectivity stronger every second between farmers and agricultural authorities. This will decrease the risk of disasters by alerting and warning the farmers before the temperature stress expected to come. During every cropping season, government authorities should make their sure visit to major agro-ecological zones for the identification of susceptible areas e.g., which areas are more prone to heat stress etc. Farmers at local scales should be educated about the chemical and pesticide usage against climate (heat) stress in plant and against outbreak of diseases. The meaningful and innovative skills among farmers should be identified, thereby strengthening them to augment their incomes. Research authorities should disseminate new crop cultivars which are resistant or bit tolerant against climate stresses. Identification of new agricultural breeds either in crops or in livestock by rearing local breeds to handle climate stresses at local level in better way. Collaborative institutes should be made in every agricultural institute to cope with climate change disasters which will address the projected impacts of climate change at every region of the state. If a disaster prevails, then most necessary step should be taken is to identify the most vulnerable group which are more like to be children, women and the older people, preventive measures should be disseminated among these vulnerable groups. Awareness among local people through local media, print media or by any local source to let them know about storage of food for near future during upcoming climate disaster (heat stress) period. Different kinds of insurance programs should be introduced for the poorest people at local scales to cope with their losses if climate disaster (heat stress) prevails and could not be avoided. Most basic point is that capacities of agricultural-based institutes should be enhanced to for the proper identification of climate change impacts, thereby devising the adaptation technologies for each agro-ecological zone.

DROUGHT STRESS AND ENSURING FOOD SECURITY

First thing to ensure the food availability, access and utilization easier in countries like Pakistan, government regulatory authorities should make their visit to make sure and identify which areas are more prone to drought and its impacts on the local livelihoods. Breeding programs should be introduced based on every region, developing new cultivars which are tolerant against drought. Awareness should be disseminated among local people regarding conservation practices of soil and water by introducing different technologies. Local farmers should be encouraged towards crop-rotation programs which also include hybrid crop cultivars. Drought-endangered areas should be practiced with incorporation of crop residues to increase the soil mulch and soil organic matter. Farmers should be encouraged to intervene their farms with those in mediations that will support their agro-farming. To make the access easier and reducing the risks of drought, financial support programs against climate stresses should be designed e.g., Benazir Income Support Program (BISP). Micro-financial insurance programs should be designed based on weather-indices and climate stresses for the extension of social safety. Using the available resources, locally based and cheap technologies should be introduced to make the local population resilient to climate stresses like drought specifically the small-holders and vulnerable groups. To make the better utilization of food during the drought stress days, balanced supply of water should be ensured specifically for vulnerable regions. During stress days, ensuring the availability of basic necessities to most prone groups should be the priority of government agencies to reduce the losses. Introducing adaptation techniques like conservation of soil and sustainable management of irrigational water specifically in stress prone areas should be the first priority. Disaster Risk Management Programs (DRM) etc. should be introduced by local government authorities as an initiative to climate change.

FLOOD STRESS AND ENSURING FOOD SECURITY

Early warning system should be devised comprehensively along with regular weather updates which can only be done through the provision of new technologies like smart phones or electronic media availability in disaster regions. At government scale, strengthening of mounds in most vulnerable regions should be done to reduce the risk of flood damage to crops. Introducing the hybrid breeds among crops and livestock that can tolerate the stagnation of water by avoiding

the diseases and pests. As described earlier, regular visits should be made by government authorities for the identification of flood-prone regions. Government bodies should identify such spots where storage points can be made by storing the rain or flood water for future use. To make the accessibility easier during flood days, regulatory authorities should be strengthened enough to mitigate the effects of flood disaster through regular monitoring of market price system. People should be encouraged before the flood comes to make sure about the storage of their necessary foods and medicine. In the countries like Pakistan, private as well as government-based food banks should be introduced in the disasters' prone regions. Among flood-prone regions, the access to roads, bridges and other transports should be ensured to fulfill the food access needs during disaster prevailing days. Before the flood disaster prevails, to minimize the flood losses to livelihoods should be the first priority. The local people should be given with water-purifying pills to ensure the clean drinking water availability. People as well as the livestock of flood-prone areas should be vaccinated against the flood associated diseases. Weather-based micro-insurance programs should be introduced at both private and government levels.

REDUCING RISK OF CLIMATE CHANGE DISASTER THROUGH PREVENTION AND MITIGATION PROGRAMS

Certainly, individual disasters at regional scale cannot be linked with climate change worldwide but it can be said surely as secondary factor to global climate change. Therefore, to reduce the intensity and frequency of disasters, there is needed a well settled collaboration among all countries. Considering the high vulnerability of Pakistan's economy to natural disasters, Pakistan should play a better role globally regarding climate change negotiations. Pakistan owns separate ministry for climate change which was set up in 2010 and later on NDMA was merged in to it to make one collaborative authority. Increased occurrence of deforestation is one of the major reasons of extreme events in Pakistan. For example, taking the example of floods in Pakistan which are mostly due to the deforestation in upland catchments, which increase the run-off of water and cause heavy soil erosions during every flood. Recently, billion tree programs were designed and implemented successfully in KPK, therefore this kind of larger scale as well as small-scale reforestation programs are needed. In rural Pakistan, the people strength is mostly compromised because the local resources are under control of elite class of that region, like landlords, and other

tribal leaders etc. Pakistan is concentrated by land ownership program, thereby mostly the poorest people are generally forced to cultivate the marginal lands which less productive and make these communities more vulnerable to climate disasters. So, there is a need to amend the law and making rules balanced for everybody. Though the authorities are there which check regularly the rivers, canals and water channels regularly but however the state is still in lack of major plan that can report the main figures of vulnerabilities all around the country through linkage with national hazards. Later, this master plan will verify to which extent a specific department is working to address a respective disaster issue.

READINESS AND PREPAREDNESS TO NATURAL DISASTER

In Pakistan the ministry for interior works round the clock to monitor the climate disasters but the levels of preparedness for all disasters is not well established like the work has been done for monitoring the flood. Climate change ministry, provincial authorities and other departments are needed to work in collaboration to reduce the risks and losses due to natural disasters. All the institutions either working under provincial or federal governments need better capacity building to deal effectively with all kinds of disasters through the country. In paper work, many kinds of authorities to deal with climate disasters exist in Pakistan but they are in lack of skilled man power and technologies access. Only Pakistan army has all kinds of skills, technological access, effective and immediate response capacity against any climate disaster. So, it is needed to make the other government institutions practical instead of only in paper work. There is a need to build up the capabilities at district level to tackle the medium scale disasters.

COPING NATURAL DISASTERS THROUGH BETTER MANAGEMENT MEASURES

The people in disasters' prone regions on basis of utilization of their own techniques and resources, cope with natural disasters individually or collectively through community-based grouping. But these all measures require huge social and financial costs. Risk reducing programs along with response mechanisms against climatic disasters will prove more influential when considering the coping measures in program designing regarding assessments. Selective programs should be introduced which will directly or indirectly be helpful financially or socially for local

communities for better resilience against disasters. Pakistani community specifically the small land holders' poorest people are more prone to disasters because of the current socioeconomic scenario of the state. To avoid the damaging disasters which include floods most prominently in Pakistan, the development agencies are needed to work on dissociating the susceptibilities and exposures from economy of the state with proper functioning. The most damaging extreme events and disasters in Pakistan could have been restrained benefiting environment, if possible, management would have taken at social, political and economic scale by provincial and federal government agencies. Countries like Pakistan need to adopt some managemental approaches to cope with disasters and their risks for post-disaster recoveries for better secured livelihoods of society with more resilience. Managemental measures to cope with risks linked with disasters, consist of two kinds of mechanisms, firstly for longer term which include mitigation and adaptation programs to prevent the disasters, and secondly include short term measures that include early or at least on time warming systems, forecasting of disasters for making ready everything, and other safety approaches.

CONCLUSION

This study provides a comprehensive review on the analysis of relationships between climate change disasters and vulnerability to Pakistan economy. It provided with evidences that where the country is in lack with technical innovations to control the climate change stresses through different mitigation and adaptation measures on different scales. It emphasized that there is a need to control climate changes by developing local and local level adaptations to minimize the human non-required interventions in every sector. One of the biggest threats on this earth in current century is climate change and its impacts on livelihoods which depend on geographical, economic and socioeconomic factors. It has been predicted that climate change will be severer in near future which will bring more disasters in countries like Pakistan because of continuous interventions to the climate either naturally or human-based. Dealing with climate change disasters for countries like Pakistan is a very complex process because of limited resources, so instead of moving towards complex processes of recovering after disasters Pakistan is need some adaptation measures against climate changes. The continuous increase in climate change stress around the globe have brought more addressable issues for Pakistan because the intensity and frequency of climate disasters is

expected to increase like drought, floods, extreme events etc. Though climate change is an international scale issue and Pakistan using its limited resources can do a very little in terms of controlling climate changes through different collaborative works with other countries. There is a need to share knowledge and experiences with different countries on the basis of the availability of resources. Pakistan is in dire need to strengthen its research on climate change, because till there is a lot of work is needed to do based on climatic data. As described earlier, Pakistan's geographic location makes varying in climate even at provincial and sometimes district scales. So, instead of doing large-scale research, the state is need to conduct the visits regularly to all regions, provinces and climatic varying districts to collect the data for adaptation measures. There is need to gauge the impacts of climate changes on poorest families because it is well-known that poorest people are most prone individuals to climate change stresses. Most effective tool against the negative impacts of climate changes is creating awareness. Key knowledge gaps regarding mitigation and adaptation approaches should be pointed out considering the negative impacts of climate change and socioeconomic factors. Regional and locally research-based programs should be started under local communities for better resilience and later on adaptation to climate changes deeper to local level. So, Pakistan using its limited resources and technical manpower should focus to move towards mitigating and adapting to climate instead of recovering after climate stress being happened.

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